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DEVELOPMENT AND PERFORMANCE EVALUATION OF SINGLE WHEEL DRIVEN BOOM SPRAYER

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ABSTRACT

Agriculture plays a vital role in Indian economy. The main problems associated with food production were weeds and pests. As manual weeding is very laborious requiring to be repeated twice or three times before crop maturity. So, chemicals are widely used for controlling disease, insects and weeds in the crop. So any improvement in the productivity related task help to increase Indian farmer's status and economy. Sprayers were mechanical devices that are specially designed to spray pesticides quickly and easily for plant protection. Sprayers enable farmers to obtain the maximum agricultural output. The conventional sprayer having the difficulties such as it needs lot of effort to push the lever up and down in order to create the pressure to spray and it gives back pain to the operator. In order to overcome these difficulties an attempt was made to develop a single wheel driven boom sprayer and its performance was evaluated against knapsack sprayer.The application rate and discharge rate of knapsack sprayer were found to be 480 L/ha and 0.576 L/min respectively. The application rate, swath width, discharge rate, nozzle angle at boom height of Single Wheel driven boom sprayer were found to be 106 L/ha, 95m, 1.21 L/min and 43.5° respectively, which were optimum. The field capacity of the knapsack sprayer was 0.072 ha/h and for single wheel driven boom sprayer was 0.08125 ha/h.

KEYWORDS: Weeding, Single Wheel, Discharge Rate, Swath Width and Sprayer

INTRODUCTION

Agriculture plays a vital role in Indian economy. Around 65% of population in the state is depending on agriculture. Although its contribution to GDP is now around one sixth, it provides 56% of Indian work force. Table 1.1 shows that share of marginal and small farmer is around 81% and land operated is 44 % in 1960-61. As far as Indian scenario is concerned, more than 75 percent farmers are belonging to small and marginal land holdings. So any improvement in the productivity related task help to increase Indian farmer's status and economy.

The Indian farmers (small, marginal, small and marginal, semi-medium) are currently using lever operated backpack sprayer. A backpack sprayer consists of tank 10 -20 litre capacity carried by two adjustable straps. Constant pumping is required to operate this which result in muscular disorder. Also, the backpack sprayer can't maintain pressure, results in drifts/dribbling. Developing adequate pressure is laborious and time consuming. Pumping to operating pressure is also time consuming. Moreover, very small area is covered while spraying. So, more time are required to spray the entire land. Back pain problems may arise during middle age due to carrying of 10-20 litre tank on back (Shivaraja Kumar. A, 2014).The conventional sprayer having the difficulties such as it needs lot of effort to push the lever up and down in order to create the pressure to spray.

Shiva raja Kumar and Parameswaramurthy (2014) developed a portable device and which has no need of any fuel to operate, which is easy to move and sprays the pesticide by moving the wheel. This wheel operated pesticide spray equipment consumes less time and avoids the pesticide from coming from front of the nozzles which will in contact of the person who sprays pesticides. M. L. Suleiman et al. (2014) developed the ground metering Animal Drawn Controlled Droplet Applicator (CDA) Shrouded Disc Sprayer which ground metering is actuated by a wheel axle mechanism employing the spray components for the uniform spray distribution at optimum height and nozzle spacing. He resulted that the optimum spray height and nozzle spacing for uniform distribution were 30 cm and 1.25 m respectively.Madaet al (2013) developed an ultra-low volume sprayer powered with dry cell battery for easy adoptability at low cost operation and maintenance. He executed his work using gravity feed reservoir for loading chemicals under laboratory and field conditions by considering the parameters such as time and discharge rate for the effective uniformity and even distribution of spray droplets. The maximum swath width of the sprayer was 1.5m. He resulted that the sprayer is capable of spraying 0.4 ha/h at one meter per second walking speed.Laukik P. Raut and Smit B. Jaiswal (2013) designed agricultural pesticide sprayer and weeder. It is suitable for spraying as well as weeding at minimum cost for the farmer so that he can afford it. The objective is to enhance labour productivity or appropriately mechanize the operation where a labour or power shortage hinders completing the task in time.Sukumaranet al,(2013) executed the study of the effect of spraying pressure and usage on discharge rate and wear of hollow cone nozzle having different nozzle tip material. Study revealed that plastic tip material could work within the permissible limit of 15 % increase in discharge rate for about 90, 35, 10 h of use at pressure of 1.0, 3.0 and 5.0 kg.cm-2, respectively. Similarly, brass tip material could work for 50, 30 and 7.5h and stainless steel for 90, 50 and 17.5 h, respectively, at these pressures.

MATERIALS AND METHODOLOGY

The fabrication of single wheel driven boom sprayer was carried out at Farm Implements and Machinery Scheme, ARI, Rajendranagar, Hyderabad.

FABRICATION AND DEVELOPMENT OF SINGLE WHEEL DRIVEN BOOM SPRAYER

The fabrication of single wheel driven boom sprayer is followed by

- Body of the Sprayer
- Handle

Figure 1: Body of Sprayer

Figure 2: Handle of Sprayer

Body of Sprayer

Hallow circular rod of 25mm diameter is used for the construction of the body of sprayer. It consists of pesticide tank, on-off valve, wheel, gears, and boom set with four nozzles. The body of sprayer is constructed in such a way that the tank and the wheel is sufficiently provided with a gear mechanism and on-off valve for the spray control respectively according to the use. It is also provided with a boom with four nozzles at one end of the body in order to cover four rows in a single walk and the handles are fitted to the other end.

Handle

The body of sprayer is being carried with the help of handles. This handles are made in 'z' shape with a view to facilitate push or pull motion of the sprayer in the field for easy handling of the boom. Handles are made of using hallow circular rods of 25mm diameter with a length of 720mm at height of 460mm from ground.

FUNCTIONAL PARTS

The functional parts of the sprayer includes

- Pesticide tank,
- Wheel and Gear connection,
- On-off valve,
- Boom set,
- Nozzles.

Pesticide Tank

Tank of 16 lit capacity with 340×190 mm dimensions is selected. A frame stand for tank is constructed in the body of sprayer with 380×225 mm suitable for the tank to fix the place at 110mm away from the handle end.

Figure 3: Pesticide Tank

Spraying is done by converting the rotatory motion of the wheel into reciprocating motion of the piston. The wheel of 480mm diameter is attached to a gear having 39 number of tooth and small gear having 13 number of tooth. Both gears are connected with chain which gives speed of 3:1 ratio. The piston is connected with the gear mechanism with the help of the connecting rod which have on & off valve

Figure 4: Wheel and Gear Connection

Figure 5: Off Valve of the Sprayer

On-Off Valve

To carry the sprayer to the field or from the field without the wastage of sprays and control the motion of the piston when not in use these on-off valves are used.

Boom Set Up

The sprayer is facilitated with boom having four nozzles at one end of the body supported with 1meter long rods vertically. The boom set is built in such a way that the boom can be adjusted at different heights and angles. Two hallow rods of 1.25m long is attached to the boom set on either directions providing the boom. The nozzles with hose pipe connections are fitted/ attached to the boom with the help of threads in such a way to have two nozzles on both sides.

Figure 6: Boom Set Up

Nozzles

The pressure from the piston outlet is supplied to the nozzles with the help of hose pipe. The nozzles of solid cone are used to the circular area coverage of spray. The nozzle is selected as per the convenience of the spray liquid in medium droplet, to cover the crop where over entire spray area.

Figure 7: Solid Cone Nozzles

RESULTS AND DISCUSSIONS

PERFORMANCE OF KNAPSACK SPRAYER

Calibration of Sprayer

By taking the test plot of 4 m^2, we have observed the rate of sprayer as 0.072 ha/h and the volume rate of the knapsack sprayer 34.56 l/h. The application rate of the knapsack sprayer observed was 480 l/ha.

PERFORMANCE OF SINGLE WHEEL BOOM SPRAYER

Discharge

Table 1: Total Sprayer Output (ml/min)

Replications	Time(min)	Nozzle Discharge(ml)				Overall Discharge(ml)	Calibrated flow(ml/min)
		1	2	3	4		
1	1	340	305	310	305	1260	1260
2	1	290	310	315	325	1240	1240
3	1	310	335	312	315	1275	1275
4	1	298	310	314	356	1278	1278

- Total sprayer output (L/min) = 1263.25 ml /min.

Travel Speed

Table 2: Travel Speed Calculation

Person	Distance(m)	Time (sec)
1	100	101.73
2	100	107.40
3	100	122.50

- Average Travel Speed of time (sec) = 110.53 sec
- Travel speed km/h = 3.25km/h

Nozzle Adjustment Angle

The readings were taken at different heights. The height of boom 460 mm provided effective spraying with nozzle adjustment angle found to be 112.41^0.

Table 3: Swath Widths and Nozzle Adjustment Angles at Different Boom Heights

S.No.	Height (cm)	Swath Width (m)	Nozzle Angle (˚)
1.	118	0.95	43.85
2.	108	0.85	42.96
3.	88	0.65	40.54
4.	68	0.55	44.03
5.	38	0.40	55.51

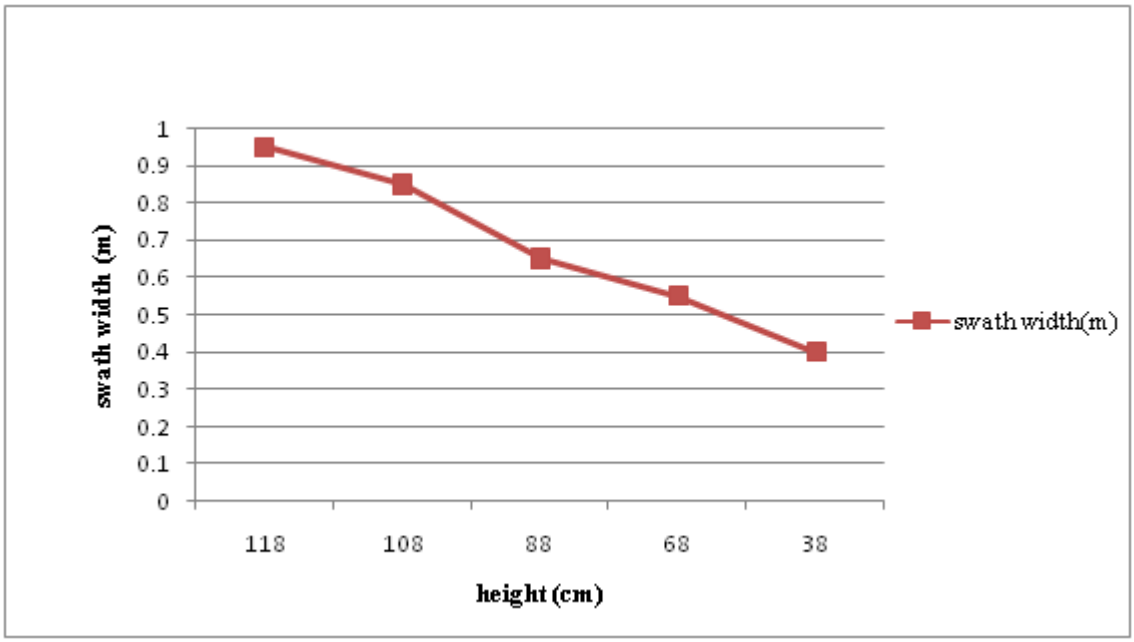

Figure 1: Variation Swath Width with Boom Height

From the Figure 1 the graph between swath width and boom height swath width of the spray increases with increasing boom heights

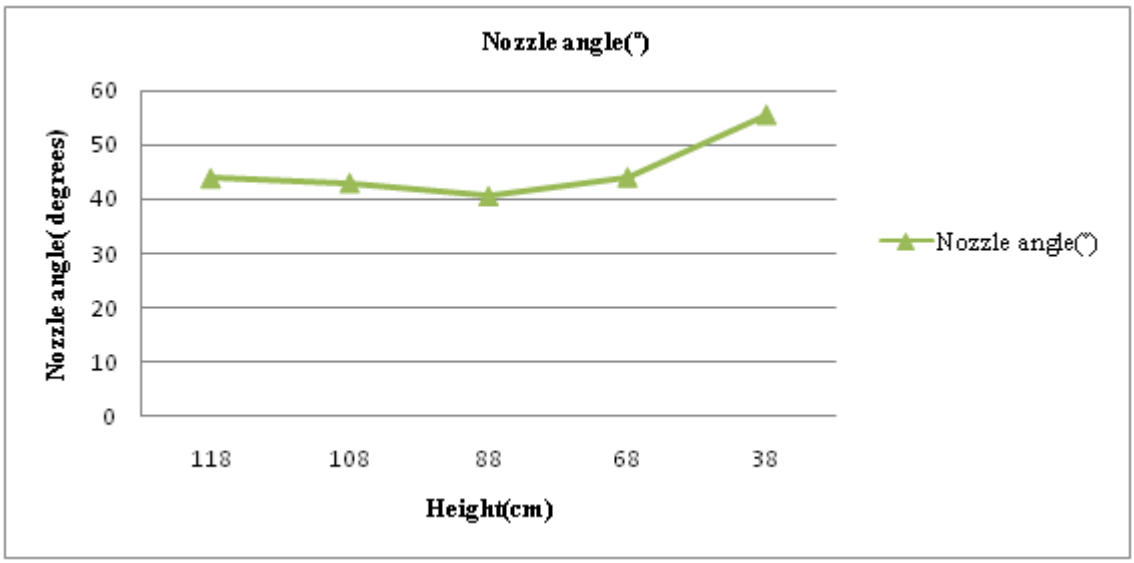

Figure 2: Variation of Nozzle Angles with Different Boom Heights

From the Figure 2 Graph between Variation of Nozzle angles with different Boom heights the nozzle angle varies with the boom height.

Field Capacity

- Theoretical Field Capacity = 0.08125ha/h
- Effective Field Capacity = 0.0658ha/h
- Field efficiency = 80.98%

The field efficiency of the single wheel driven boom sprayer was 80.98%

MEASUREMENT OF DISCHARGE RATE AND SWATH WIDTH AT DIFFERENT BOOM HEIGHTS

Table 4: Representation of Swath Width and Height of the Boom

S.No.	Height (cm)	Swath Width (m)
1.	118	0.95
2.	108	0.85
3.	88	0.65
4.	68	0.55
5.	38	0.40

PERCENT OF SPRAY OVERLAP ACCORDING TO DIFFERENT HEIGHT AND SWATH WIDTH

Table 5: Calibration of Spray Overlaps at Different Swath Widths of Boom Sprayer

Height	Swath Width	Nozzle angle	Spray Overlap(cm)	% Overlap	Nozzle spacing(cm)
118 (max. height)	95	43.85	5	5.15	90
			35	58.33	60
			50	111.1	45
108	82	41.57	---	----	90
			22	37	60
			37	82.2	45
88	65	40.54			
			-	-	90
			5	33	60
			20	44.44	45
68	55	44.03	-	-	90
			-	-	60
			10	22.22	45
38(min height)	40	55.517	-	-	90
			-	-	60
			-	-	45

However the nozzles having spray fan angles less than 110˚ could reduce the risk of drift, when using boom/nozzle heights of greater than 500 mm (miller, 2004). As the spray angles of single wheel driven boom sprayer was less than 110˚, the effect of drift was minimum at the height greater than 0.5m.

Table 6: Comparisons between Knapsack and Single Wheel Driven Boom Sprayer

S.No.	Particular	Knapsack Sprayer	Wheel Driven Boom Sprayer
1	Crops	All crops at pre emergence stage	Cotton, chillies at pre emergence stage
2	Discharge	0.576 l/min	1.2 l/min
3	Pressure	2-2.5 kg/cm^2	1.8-2.2 kg/cm^2
4	Application rate	480 l/ha	106 l/ha
5	Field capacity	0.072 ha/h	0.08125 ha/h
6	No.ofrows covered	2	4
7	Spray angle	Specified by manufacturers	Varies with height of boom

Table 6 Contd.			
8	Overlap	-	Varies with different height and nozzle spacing
9	Height	Based on crop	Based on crop
10	Speed of operator	3.68 km/h	3.25 km/h

CONCLUSIONS

The following conclusions were drawn from the test data:

1. This sprayer gives the application rate of 106 litres/ha.
2. It requires a short time period per unit area spraying, the field capacity of the sprayer is 0.8125 ha/h which is one of the most prerequisite of a low volume spraying technique.
3. This sprayer is useful for treating the different crop heights by the adjustment of boom heights.
4. It is useful in early crop growth stage in cotton, chilli and also useful in low height crops like vegetables, groundnut, soya-bean and oilseed crops at the pre-emergency stage for spraying.
5. It can be successively used for spraying insecticide, fungicide and also herbicide of water soluble formulations, because of there is no agitator in the system.

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